Principles of Software Construction: Objects, Design, and Concurrency

Part 2: Design case studies

Design case study: Java Swing

Charlie Garrod Chris Timperley

Administrivia

- Reading due today: UML and Patterns 26.1 and 26.4
- Homework 4b due Thursday, October 17th

https://commons.wikimedia.org/wiki/File:1_carcassonne_aerial_2016.jpg

Key concepts from Thursday

- Observer design pattern
- Introduction to concurrency
  - Not enough synchronization: safety failure
  - Too much synchronization: liveness failure
- Event-based programming
- Introduction to GUIs

GUI programming is inherently multi-threaded

- Swing *event dispatch thread* (EDT) handles all GUI events
  - Mouse events, keyboard events, timer events, etc.
- No other time-consuming activity allowed on the EDT
  - Violating this rule can cause liveness failures

Swing has many event listener interfaces

- `ActionListener`
- `AdjustmentListener`
- `FocusListener`
- `ItemListener`
- `KeyListener`
- `MouseListener`
- `TreeExpansionListener`
- `TextListener`
- `WindowListener`
- …

```
class ActionEvent {
        int when;
        String actionCommand;
        int modifiers;
        Object source();
        int id;
```

```
interface ActionListener {
        void actionPerformed(ActionEvent e);
}
```


isr institute for SOFTWARE RESEARCH

Aside: lambdas vs. explicit class declarations?

```
//static public void main…
JFrame window = …

JPanel panel = new JPanel();
window.setContentPane(panel);

JButton button = new JButton(“Click me”);
button.addActionListener(new ActionListener() {
      public void actionPerformed(ActionEvent e) {
            System.out.println(“Button clicked”);
      }
});
panel.add(button);

window.setVisible(true);
```

panel to hold the button

register callback function

callback function implements ActionListener interface

isr institute for SOFTWARE RESEARCH

Aside: lambdas vs. explicit class declarations?

```
//static public void main…
JFrame window = …

JPanel panel = new JPanel();
window.setContentPane(panel);

JButton button = new JButton("Click me");
button.addActionListener( (e) -> {
             System.out.println("Button clicked");
});
panel.add(button);

window.setVisible(true);
```

panel to hold the button

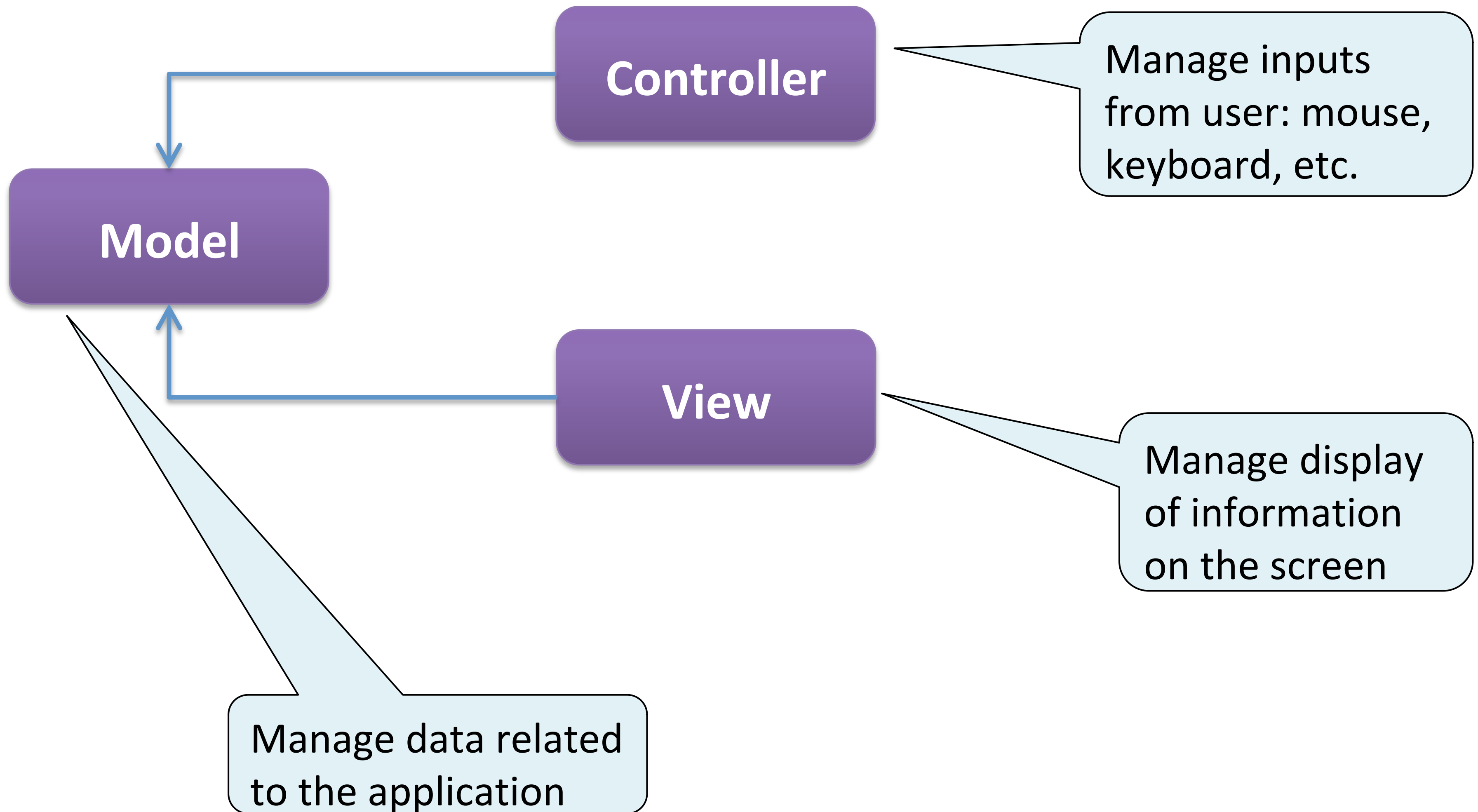
register callback function

callback function implements ActionListener interface

institute for SOFTWARE RESEARCH

Design discussion: Decoupling your game from your GUI

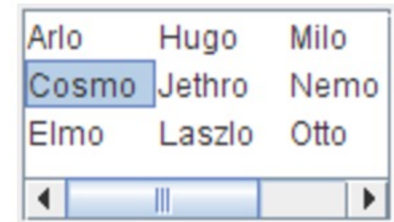
An architectural pattern: Model-View-Controller (MVC)



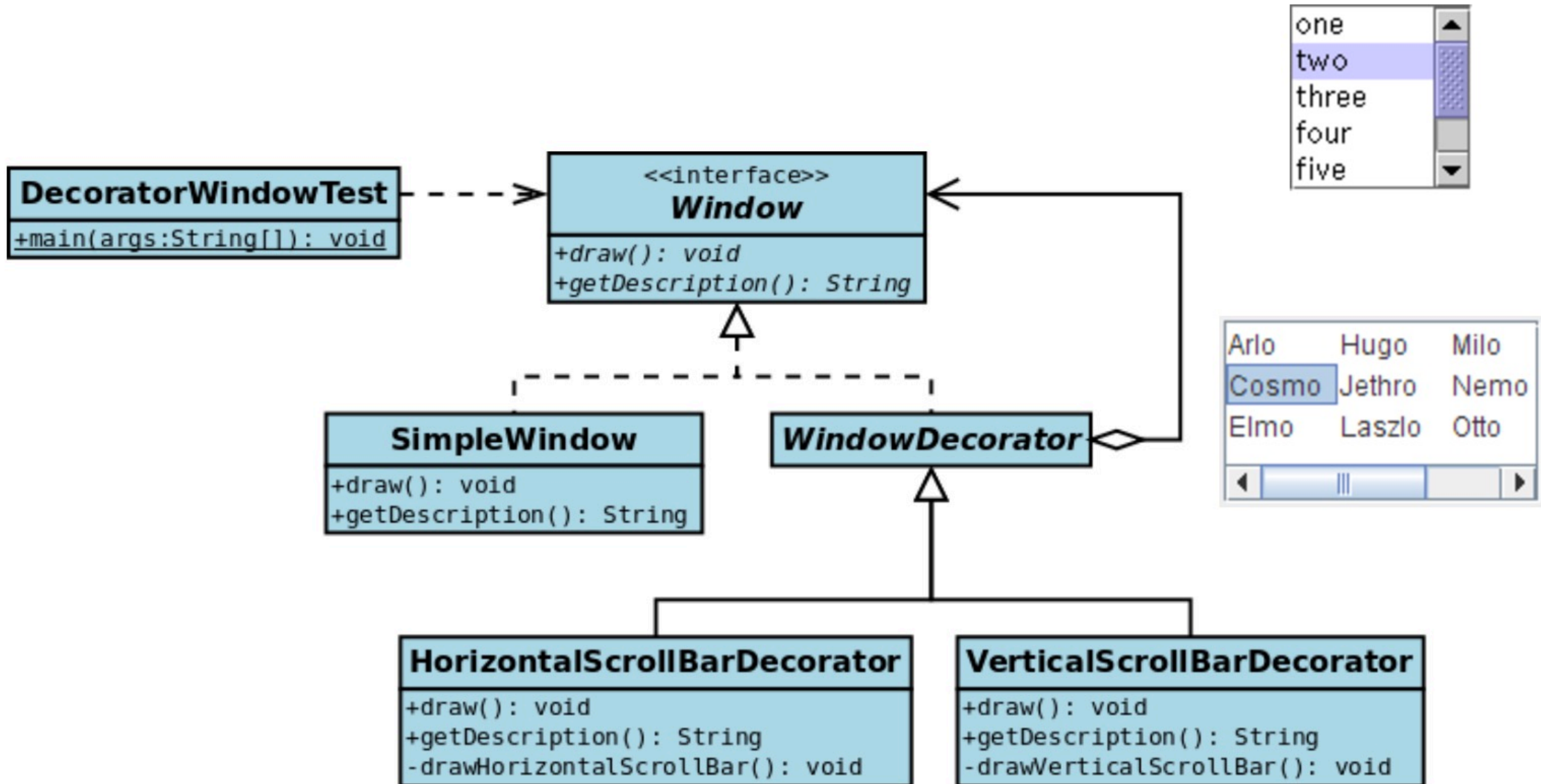
Today

- Design case study: GUI potpourri
  - Strategy
  - Template method
  - Observer
  - Composite
  - Decorator
  - Adapter
  - Façade
  - Command
  - Chain of responsibility
- An exercise in design patterns

The decorator pattern abounds



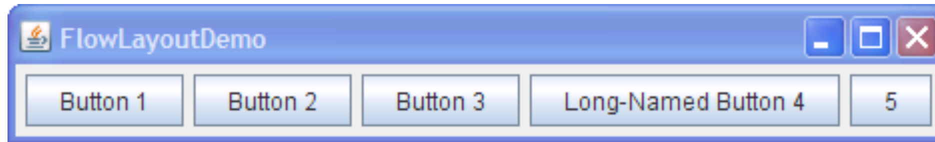
The decorator pattern abounds



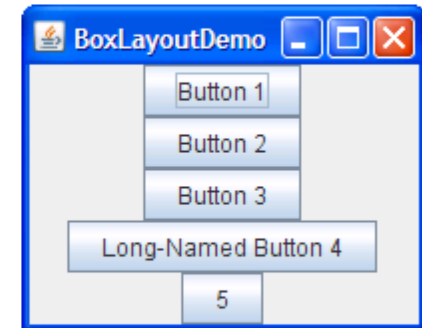
UML from https://medium.com/@dholnessii/structural-design-patterns-decorator-30f5a8c106a5

isr institute for SOFTWARE RESEARCH

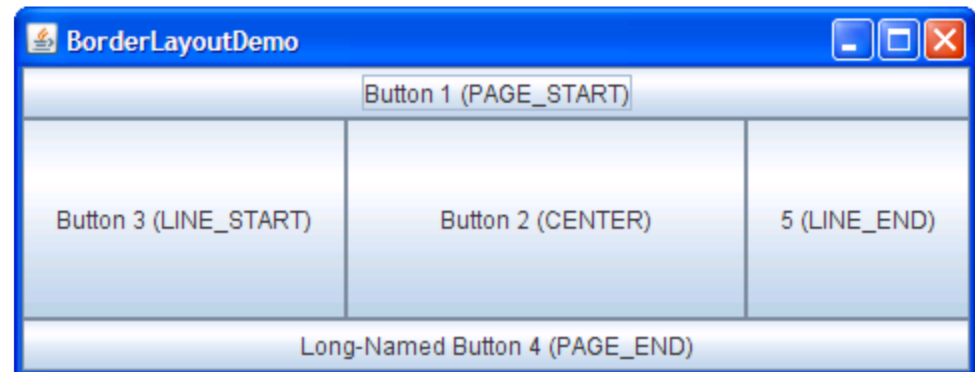
Swing layouts



The simplest, and default, layout.
Wraps around when out of space.



Like FlowLayout, but no wrapping



More sophisticated layout managers

see http://docs.oracle.com/javase/tutorial/uiswing/layout/visual.html

A naïve hard-coded implementation

```
class JPanel {
      protected void doLayout() {
        switch(getLayoutType()) {
                case BOX_LAYOUT: adjustSizeBox(); break;
                case BORDER_LAYOUT: adjustSizeBorder(); break;
                ...
        }
      }
      private adjustSizeBox() { … }
}
```

- A new layout would require changing or overriding JPanel

isr institute for SOFTWARE RESEARCH

A better solution: delegate the layout responsibilities

- Layout classes, e.g.:

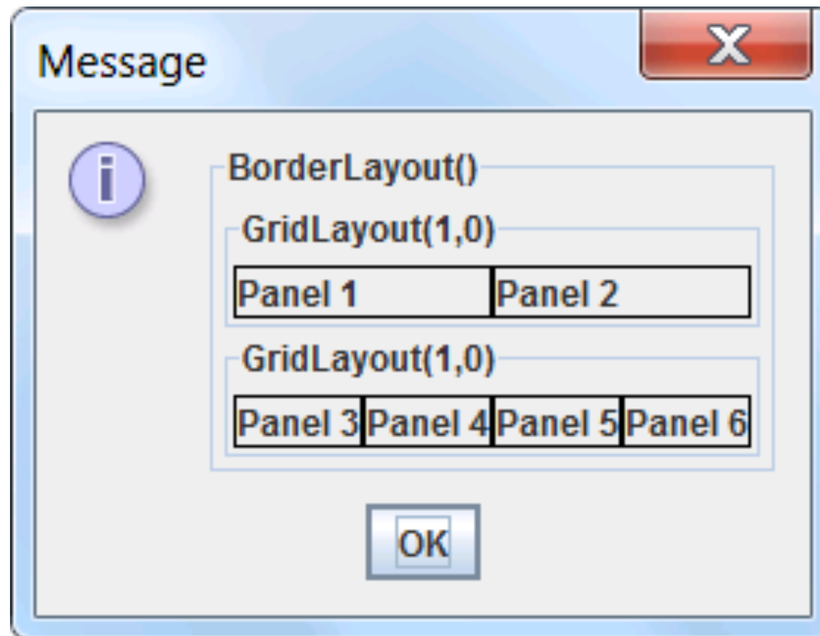
```
contentPane.setLayout(new FlowLayout());
contentPane.setLayout(new GridLayout(4,2));
```

- Similarly, there are border classes to draw the borders, e.g.:

```
contentPane.setBorder(new EmptyBorder(5, 5, 5, 5));
```

Another GUI design challenge: nesting containers

- A `JFrame` contains a `JPanel`, which contains a `JPanel` (and/or other widgets), which contains a `JPanel` (and/or other widgets), which contains…



The composite pattern

- Problem: Collection of objects has behavior similar to the individual objects
- Solution: Have collection of objects and individual objects implement the same interface
- Consequences:
  - Client code can treat collection as if it were an individual object
  - Easier to add new object types
  - Design might become too general, interface insufficiently useful

Recall: Creating a button

```
//static public void main…
JFrame window = …

JPanel panel = new JPanel();
window.setContentPane(panel);

JButton button = new JButton(“Click me”);
button.addActionListener( (e) -> {
             System.out.println(“Button clicked");
});
panel.add(button);

window.setVisible(true);
```

callback function implements ActionListener interface

register callback function

institute for SOFTWARE RESEARCH

An alternative button

```
class MyButton extends JButton {
   public MyButton() { super("Click me"); }
   @Override
   protected void fireActionPerformed(ActionEvent e) {
      super.fireActionPerformed(e);
      System.out.println("Button clicked");
   }
}

//static public void main…
JFrame window = …
JPanel panel = new JPanel();
window.setContentPane(panel);
panel.add(new MyButton());
window.setVisible(true);
```

Design discussion: Strategy vs. template method patterns

```
//static public void main…
JFrame window = …

JPanel panel = new JPanel();
window.setContentPane(panel);

JButton button = new JButton("Click me");
button.addActionListener( (e) -> {
                System.out.println("Button clicked");
});
panel.a

window.
```

```
class MyButton extends JButton {
   public MyButton() { super("Click me"); }
   @Override
   protected void fireActionPerformed(ActionEvent e) {
       super.fireActionPerformed(e);
       System.out.println("Button clicked");
   }
} …
```

Better use of template method: partial customization

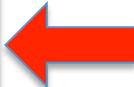
`JComponent:`

paint

```
public void paint(Graphics g)
```

Invoked by Swing to draw components. Applications should not invoke `paint` directly, but should instead use the `repaint` method to schedule the component for redrawing.

This method actually delegates the work of painting to three protected methods: `paintComponent`, `paintBorder`, and `paintChildren`. They're called in the order listed to ensure that children appear on top of component itself. Generally speaking, the component and its children should not paint in the insets area allocated to the border. Subclasses can just override this method, as always. A subclass that just wants to specialize the UI (look and feel) delegate's `paint` method should just override `paintComponent`.

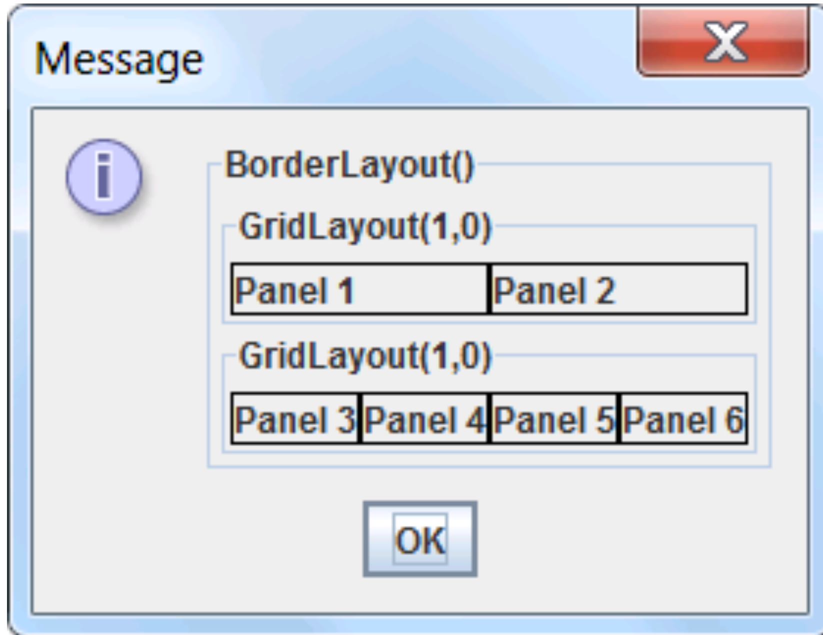


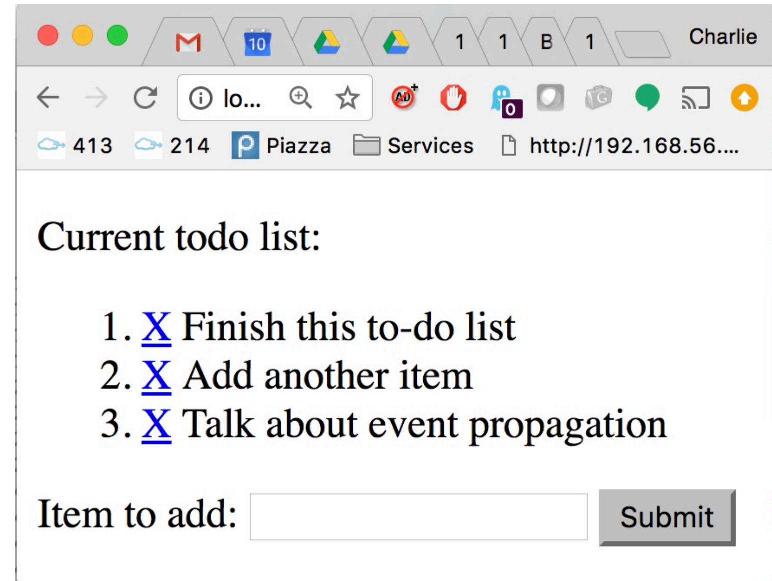
Overrides:

`paint` in class `Container`

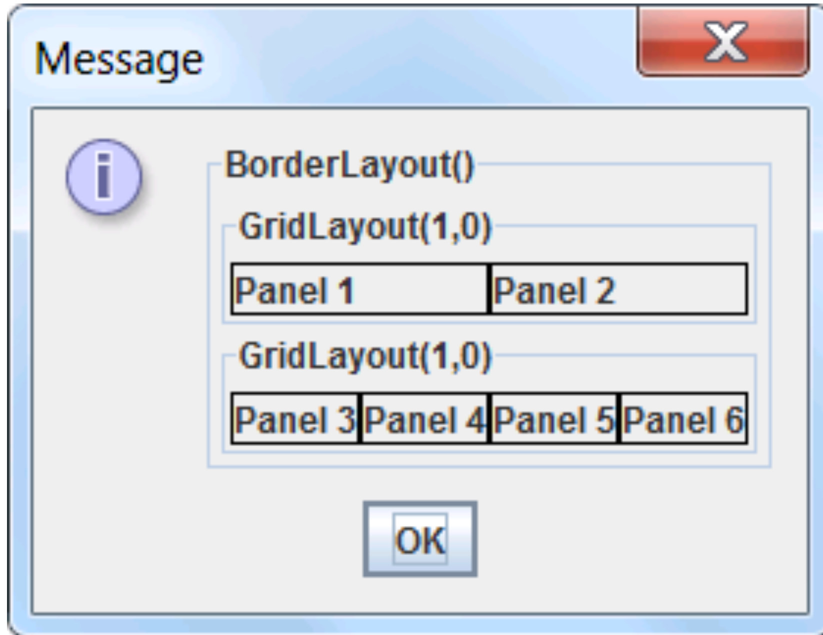
Parameters:

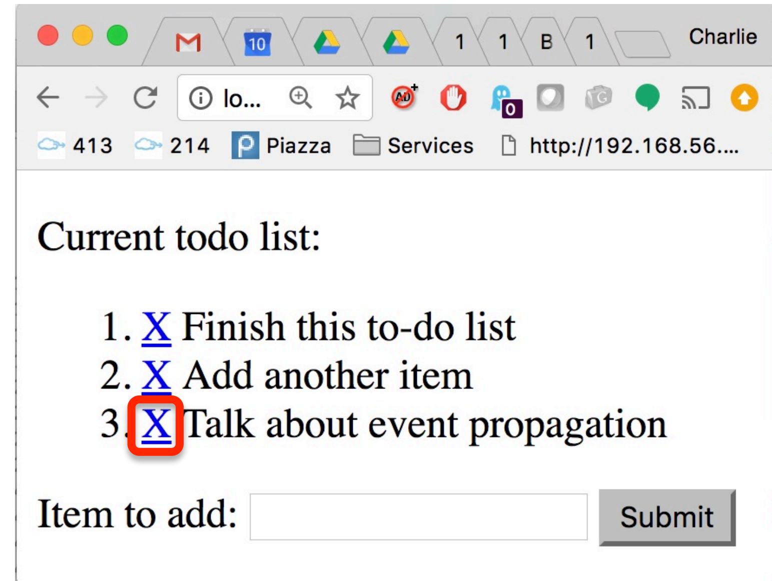
Event propagation and deep container hierarchies



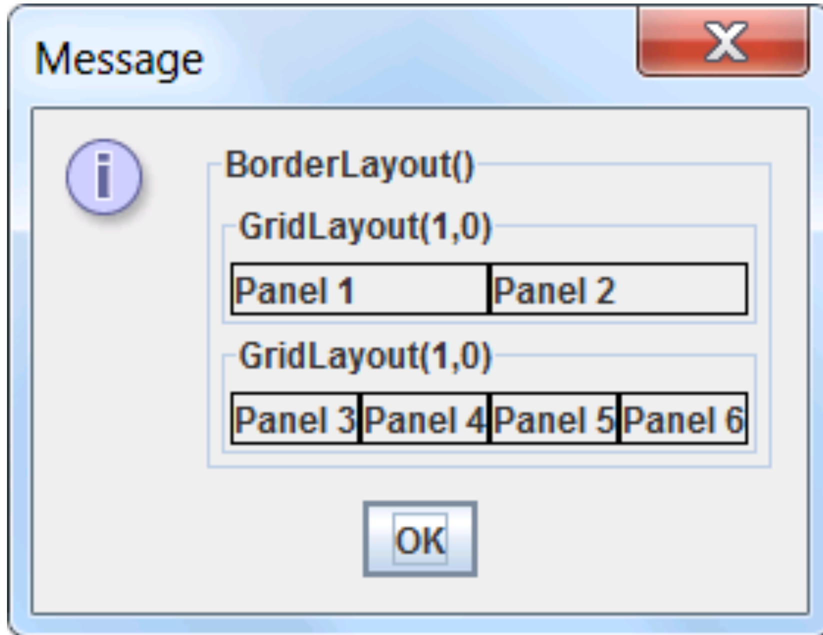


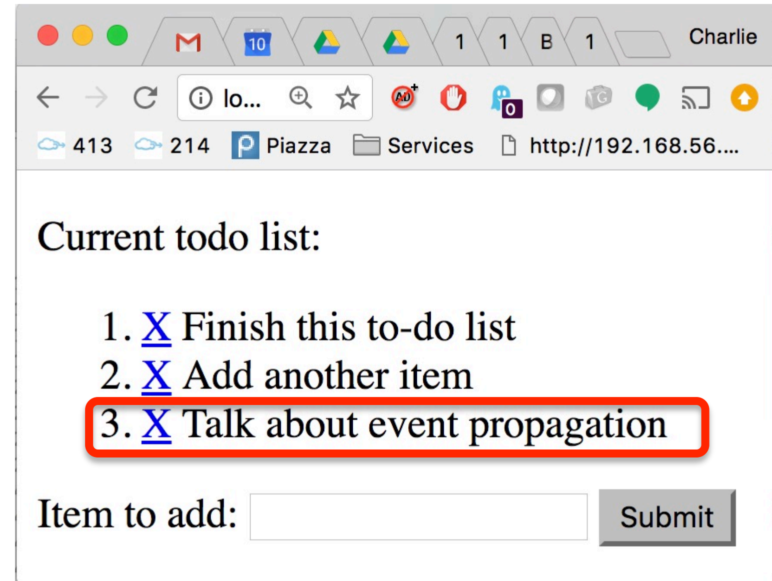
Event propagation and deep container hierarchies



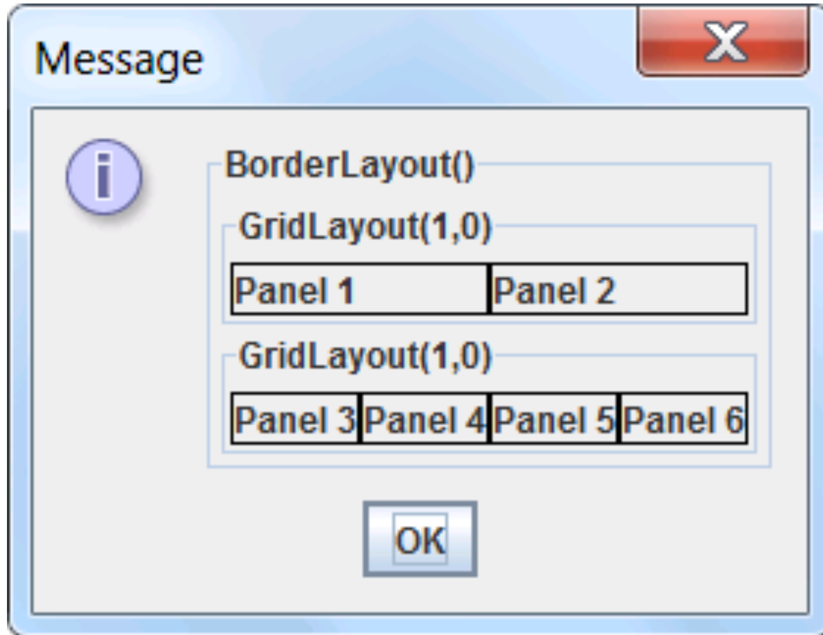


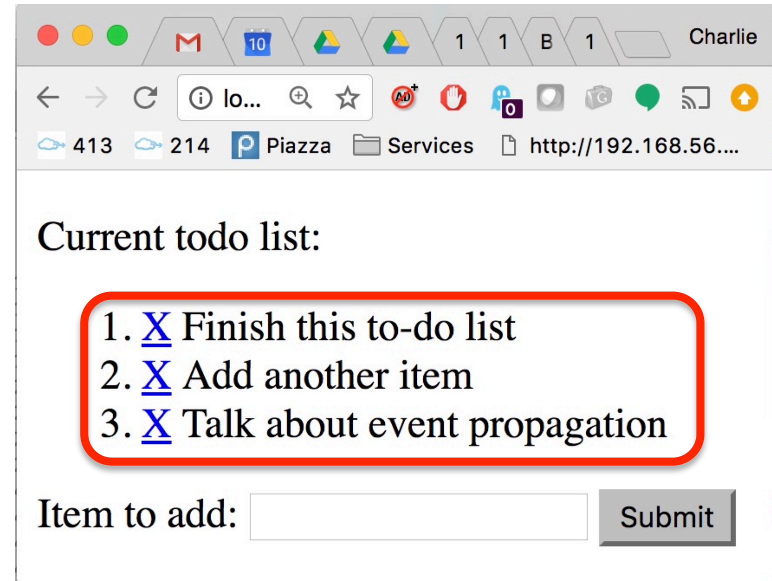
Event propagation and deep container hierarchies



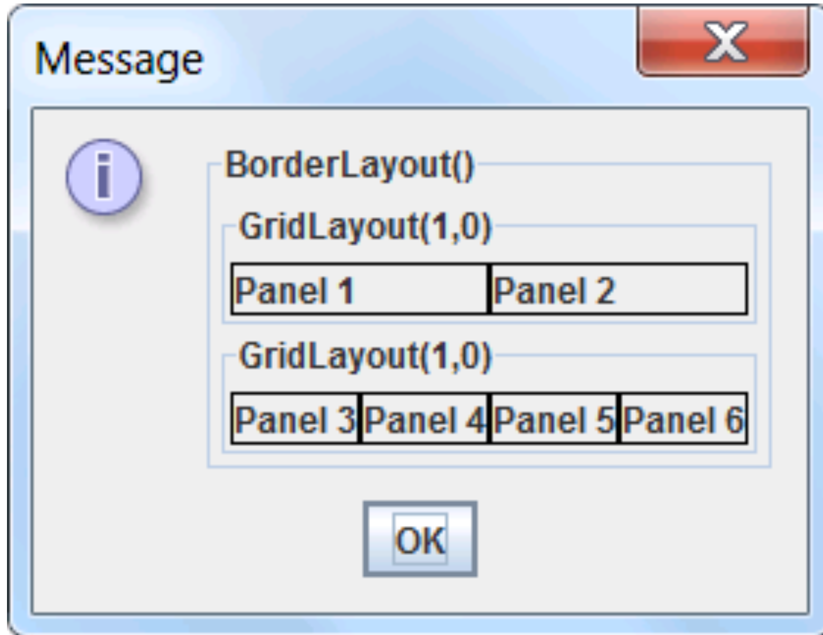


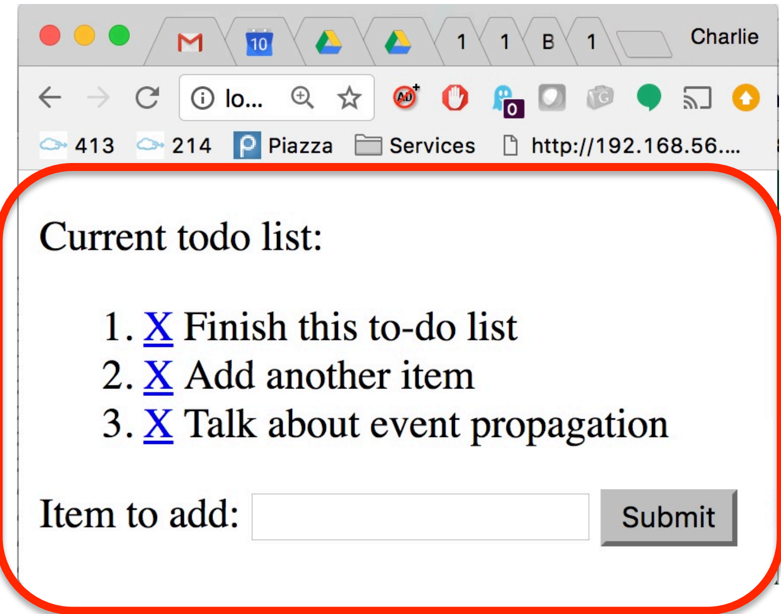
Event propagation and deep container hierarchies





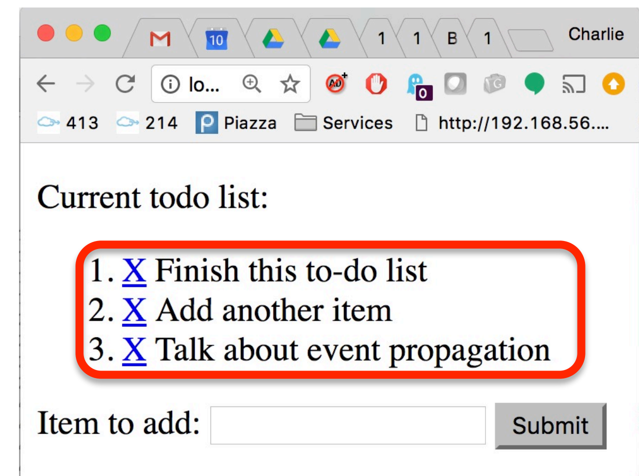
Event propagation and deep container hierarchies





The chain of responsibility pattern

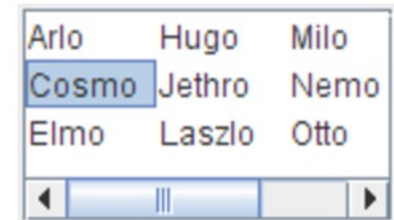
- Problem: You need to associate functionality within a deep nested or iterative structure, possibly with multiple objects
- Solution: Request for functionality, pass request along chain until some component handles it
- Consequences:
  - Decouples sender from receiver of request
  - Can simplify request-handling by handling requests near root of hierarchy
  - Handling of request not guaranteed



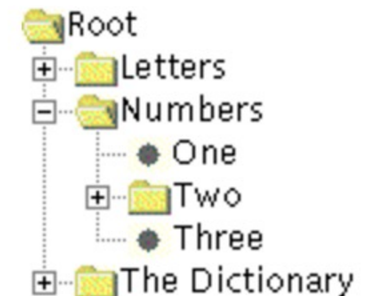
isr institute for SOFTWARE RESEARCH

The design of `JList` and `JTree`

- Highly flexible rendering of lists and trees
  - Can change rendering of cells
  - Can change source of data to display




```
// example of simple use
String [] items = { “a”, “b”, “c” };
JList<String> list = new JList<>(items);
```



Using `JLists` with a `ListModel`

- Allows a list widget (the view) to react to changes in the model

```
// with a ListModel
ListModel<String> model = new DefaultListModel<>();
model.addElement(“a”);
JList<String> list = new JList<>(model);
```

```
interface ListModel<T> {
      int getSize();
      T getElementAt(int index);
      void addListDataListener(ListDataListener l);
      void removeListDataListener(ListDataListener l);
}
```

Using `JLists` with a `ListModel`

- Allows a list widget (the view) to react to changes in the model

```
// with a ListModel
ListModel<String> model = new DefaultListModel<>();
model.addElement("a");
JList<String> list = new JList<>(model);
```

```
interface ListModel<T> {
      int getSize();
      T
      v
      v
}
```

```
interface ListDataListener extends EventListener {
      void intervalAdded(…);
      void intervalRemoved(…);
      void contentsChanged(…);
}
```


institute for SOFTWARE RESEARCH

Attaching a data source to a JList

- Assume we have an anagram generator, and we want to update a JList with new anagrams as they are generated

```
// design 1
class AnagramGen implements ListModel<String> {
      List<String> items …

      int getSize() { return items.size(); }
      String getElementAt(int index) {
            items.get(index).toString();
      }
      void addListDataListener(ListDataListener l) {…}
      …
}
```


isr institute for SOFTWARE RESEARCH

Attaching a data source to a JList

- Assume we have an anagram generator, and we want to update a JList with new anagrams as they are generated

```
// design 2
class AnagramGen {
      DefaultListModel<String> items …

      public ListModel<String> getListModel() {
            return items;
      }
      public Iterable<String> getItems() {
            return items.elements();
      }
      …
}
```

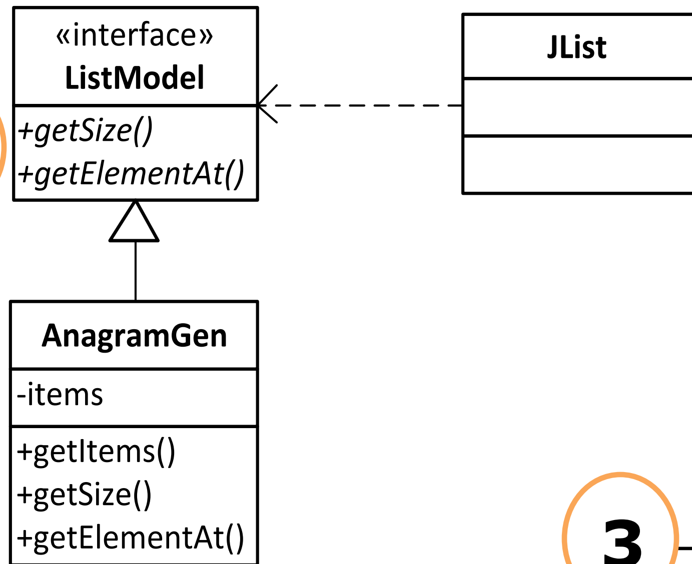
Attaching a data source to a `JList`

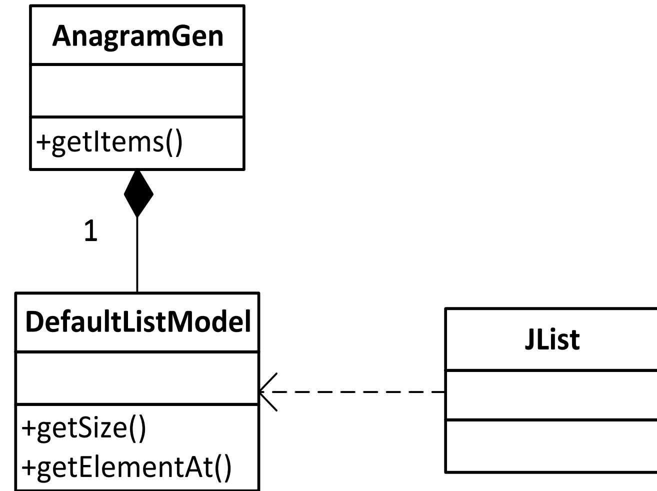
- Assume we have an anagram generator, and we want to update a `JList` with new anagrams as they are generated

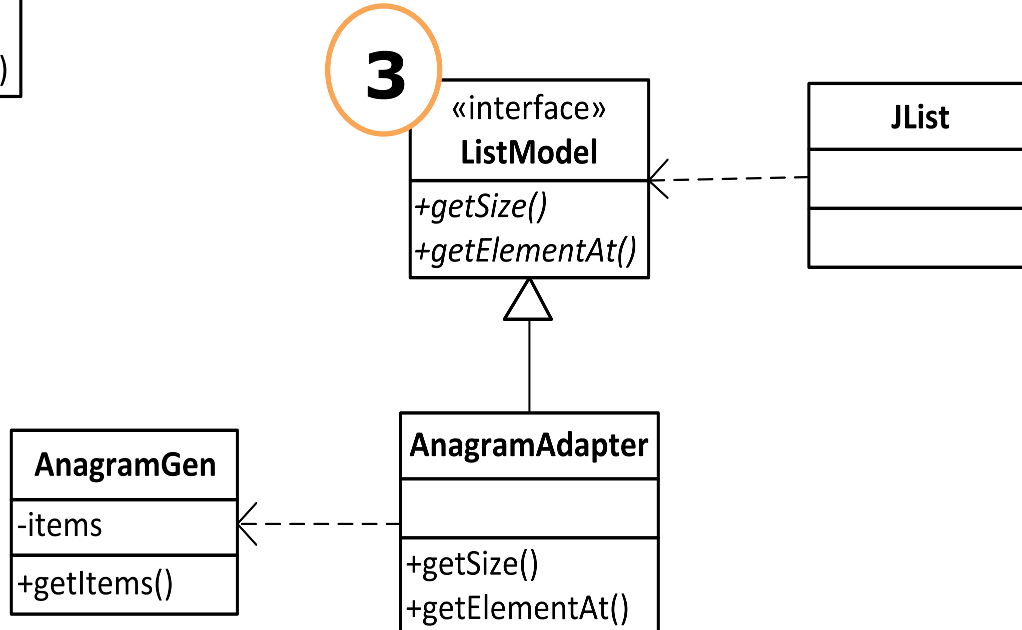
```
// design 3
class AnagramAdapter implements ListModel<String> {
        private final AnagramGen an;
        public AnagramAdapter(AnagramGen s) {an = s;}

        int getSize() { return count(an.getWords()); }
        String getElementAt(int index) {
                find(an.getWords(), index).toString();
        }
        void addListDataListener(ListDataListener l) {…}
        …
}
```


institute for SOFTWARE RESEARCH

Comparing the three proposed designs







The adapter pattern

- Problem: You have a client that expects one API for a service provider, and a service provider with a different API
- Solution: Write a class that implements the expected API, converting calls to the service provider's actual API
- Consequences:
  - Easy interoperability of unrelated clients and libraries
    - Client can use unforeseen future libraries
  - Adapter class is coupled to concrete service provider, can make it harder to override service provider behavior

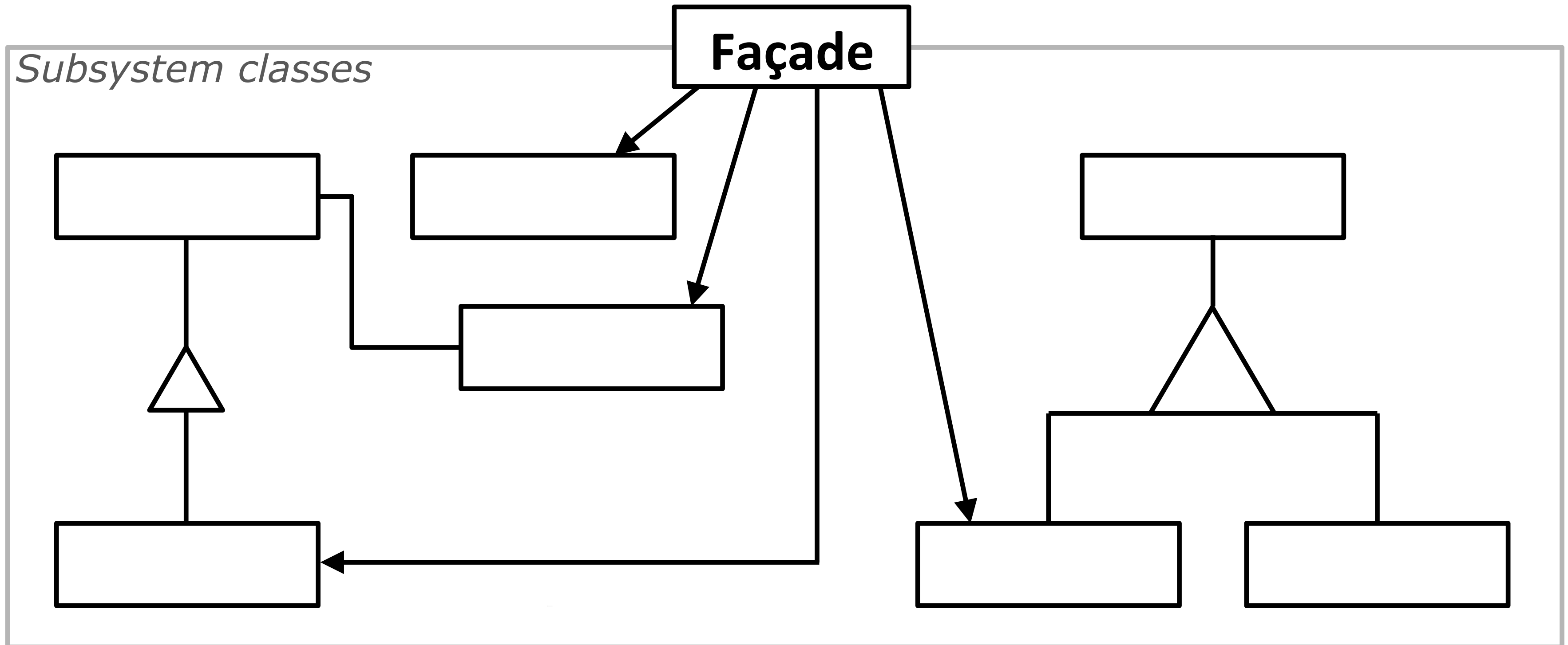
The adapter pattern, illustrated

Have this

and this?

Use this!

Aside: The façade pattern



isr institute for SOFTWARE RESEARCH

The façade vs. adapter patterns

- Motivation:
  - Façade: Provide simple interface for a complex API
    - Façade interface is typically *new*
  - Adapter: Match interface expected by an existing client to existing API
    - Adapter interface is defined by the existing client's expectations

Today

- Design case study: GUI potpourri
  - Strategy
  - Template method
  - Observer
  - Composite
  - Decorator
  - Adapter
  - Façade
  - Command
  - Chain of responsibility
- An exercise in design patterns

Design patterns we have seen so far

Factory method

Composite

Adapter

Decorator

Model-View-Controller

Iterator

Strategy

Façade

Template method

Command

Observer

Chain of responsibility

Design patterns we have seen so far

Composite

Adapter

Factory method

Decorator

Model-View-Controller

Iterator

Strategy

Façade

Template method

Command

Observer

Chain of responsibility

A note on design

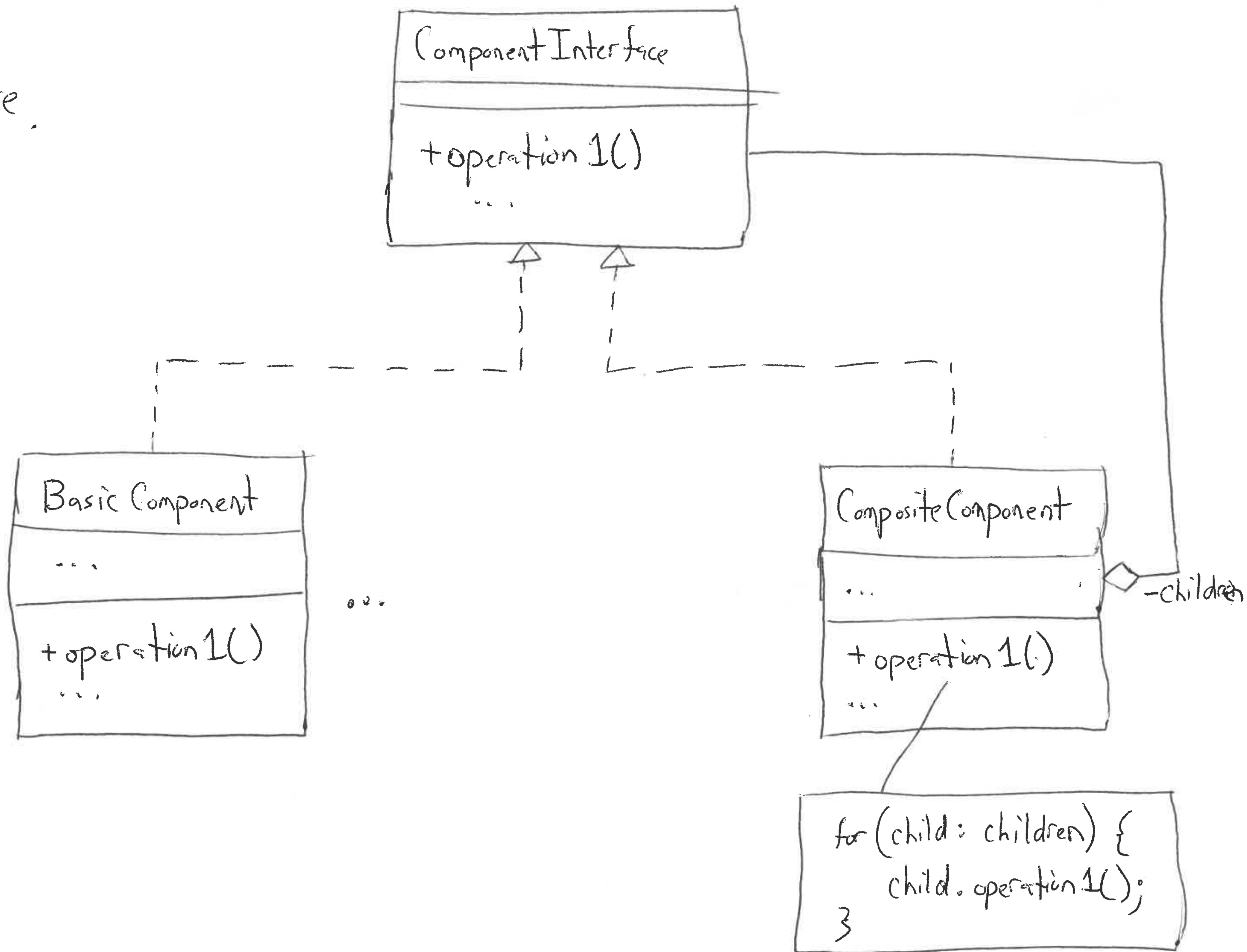
- The previous exercise is backward
  - "Here's a design pattern. Now use it."
- The real exercise: "How do I design this program to accomplish my goals?"
  - "Aha! I've seen this problem before!"

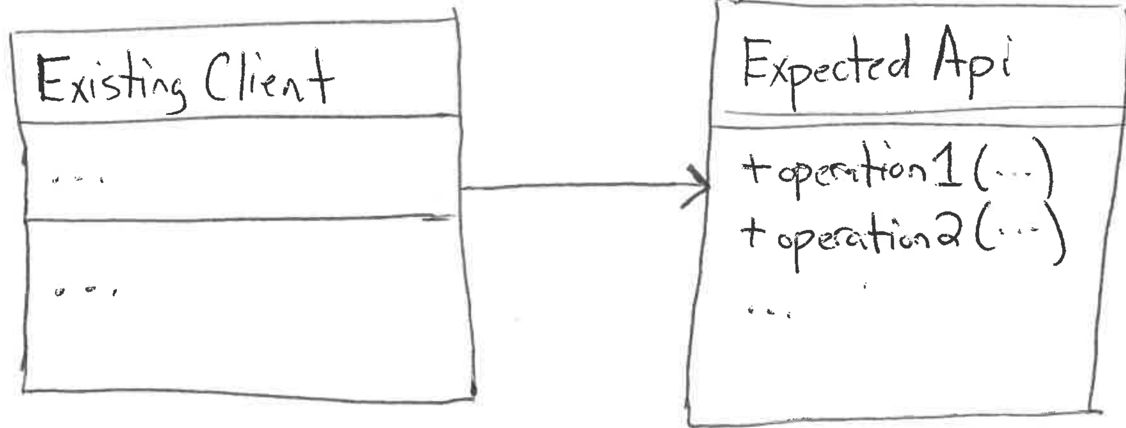
Next time

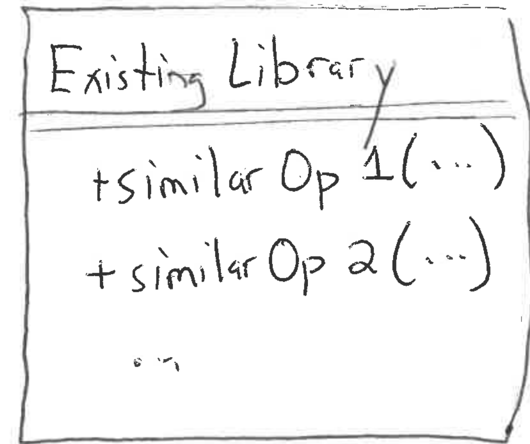
- Design case study of Java Collections

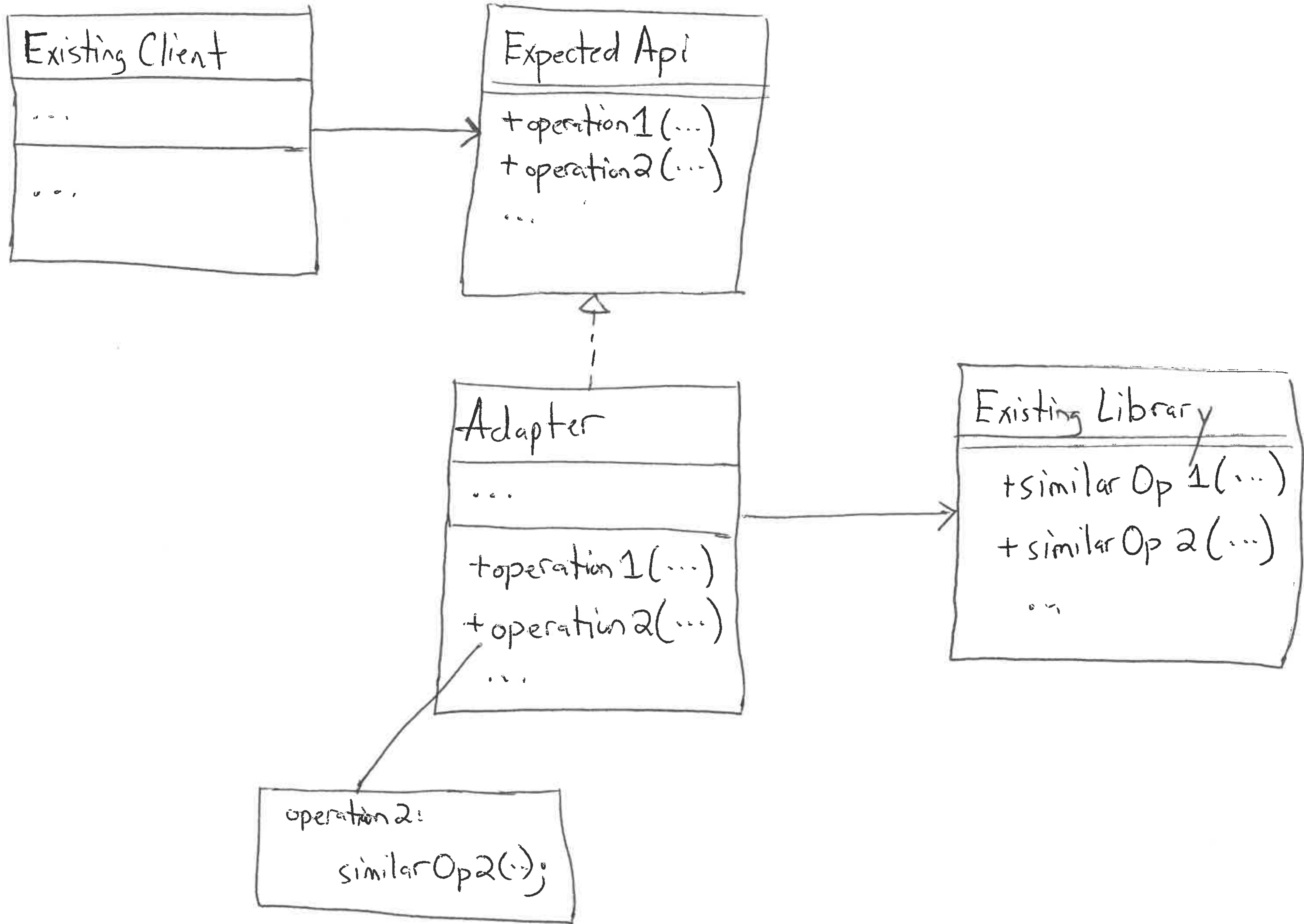
Paper slides from lecture are scanned below..

Generic Composite Pattern




Existing Client
...
...
Expected Api
+operation1(...)
+operation2(...)
...


Existing Library
+similarOp1(...)
+similarOp2(...)
...



Existing Client
...
...
Expected Api
+operation1(...)
+operation2(...)
...
Adapter
...
+operation1(...)
+operation2(...)
...
Existing Library
+similarOp1(...)
+similarOp2(...)
...
operation2:
similarOp2(..);